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Music Enhances Learning

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"Music Enhances Learning" represents the motivation for my thesis study. The twenty-first century begins with research that affirms the role of music in brain function before birth through childhood and into adulthood. My research analyzes the effects of musical stimulation on the prenatal fetus and the postnatal infant. The main body of the research focuses on how music improves learning in the preschool, school and college settings. The studies I compiled investigate supporting evidence that music increases intelligence, leads to cognition and basic skills development, and raises academic achievement scores. My research explains the importance and benefits of music in the learning process and supports music as an integral part of core curriculum.

New studies on music and learning have developed from an expanding body of research from neuroscience laboratories on the development of the brain. Studies conclude that at birth children have billions of unconnected or loosely connected neurons or brain cells. Every experience, from seeing a parent's smile to hearing a person sing, strengthens or bonds the connection between cells. Unused pathways in the brain die. The neural connections are responsible for all types of intelligence. Thus, exposure to enriching experiences in early childhood is essential for the full development of a child's brain (Shaw 53-72).

A growing body of evidence from research studies confirms that musical experiences affect brain development and learning. The nervous system and brain of the prenatal fetus has an inborn capacity to respond to musical sound as stimuli. Recent scientific evidence confirmed that the infant's ear begins development a few weeks after conception. The auditory system of the infant's brain starts to function around the twenty-sixth week, or the last trimester of pregnancy. A fetus responds to external sound through changes in heart rate and body movement (Weinberger, Lessons 2-3). Normal levels of sound slow the heart rate for an instant and trigger the "What is it? response." Loud music creates a startle response and speeds the heart rate (Jensen 24). Because of the liquid and tissue around the fetus, outside sounds are altered. Minor effects occur with sounds an infant hears below middle C on the piano, but a reduction of sound levels increase with higher notes. Few alterations occur with infants in changes of melody and rhythm. *Beethoven's Fifth Symphony* is an example. When the symphony was played the sound reached the fetal ear with a clearly recognizable sound image (Weinberger, Lessons 2). The reduction of response by the fetus to repeated sounds induced habituation, a simple type of learning where there is less attention to familiar things (Jensen 24). As early as 1948, research reflected fetal memory. Studies concluded that a mild vibratory stimulus placed on the mother's abdomen produced no significant fetal response, but the loud sound that followed evoked movement. After the paired stimuli were introduced several times, the fetus anticipated the loud sound to follow the vibration as evidence of associative learning (Weinberger, Lesson 3).

The long-term cognitive benefits of prenatal music exposure are difficult to measure. There are two forms of measurement for the postnatal effects of prenatal music: studies that assess the rate of behavioral development after birth and studies that measure the amount of prenatal learning evident in postnatal memory. The following scientific evidence supports the conclusion that music facilitates infant development.

Researchers presented examples of music's value on prenatal development in two studies. In the first study expectant mothers listened to music, rocked and patted the abdomen from the twenty-eighth to the thirty-sixth week of the gestational period. After birth, early development of the infant's ability to follow the voice of the mother was documented. The weakness of the study in reference to music is that other stimuli were used such as rocking and patting. (Weinberger, Lesson 3-4).

The second study divided one hundred and seventy-two expectant mothers into experimental and control groups. Beginning at the twenty-eighth week and continuing to delivery, mothers listened to an average of seventy hours of taped violin music. Basic elements of the music advanced from a three note major chord to increasingly complex chords. The instrument, "Observational Scales of Development," was used to chart the behavior of the infants from zero to six months. Experimental group participants demonstrated more advanced development in gross and fine motor skills, in linguistics, in some body-sensory coordination and in specific cognitive behaviors. Behaviors that developed faster were babbling, following objects visually, eye-hand coordination, exploring objects with the mouth, facial imitations, general motor coordination and holding the bottle with two hands. The infants' mothers assessed the development. The validity and reliability of the study would have improved if an outside researcher had observed the experimental mothers (Campbell 23-24). The study shows that musical sounds are among the first stimuli to which an infant responds and incorporates into learning activities.

In a study of prenatal and postnatal responses to music, expectant mothers watched a television show which played a particular theme song three hundred and sixty times. During the thirty-sixth and thirty-seventh week of the pregnancy, the fetus responded to the theme song music with movement. After birth the infant's heart rate decreased as a response to hearing the same theme song music. Listening to unfamiliar musical pieces failed to illicit a similar response. The study concluded that learning takes place in the prenatal stage. A fetus retained learning and postnatal memory after birth. The infants in this study responded to a specific piece of music before and after birth (Weinberger, Music of the Womb 1-6).

Dr. Jayne Standley, Professor of Music Therapy at Florida State University, has numerous published research studies on music and infant development. The "Pacifier-Activated Lullabies" study involved premature infants that needed to develop the sucking reflex in order to get the needed nutrition for growth. A sensor placed in the pacifiers played music when the baby sucked. The infants quickly learned that sucking would produce the musical lullabies, and sucking in the premature infants increased. Thus, premature infants can respond to musical stimuli and appear to enjoy the auditory characteristics of lullabies (Weinberger, Arts Education 8-9).

Researchers at St. John's University and Iona College discovered that music could be a learning tool at the early age of three months. The infants learned to move an overhead crib mobile when one of two pieces of music was played. A ribbon was placed on the infant's ankle and attached to the mobile stand. When music was played, the infants kicking produced mobile movement. The infants quickly learned that the musical cues allowed them to move the mobile. Researchers noted that the infants kicked more when the music was played. The study revealed the ability of very young infants to use music for memory retrieval (Weinberger, Briefly Noted 8-9).

A listening exercise demonstrated that infants have highly developed cognitive reasoning abilities and respond to the structure of music. Infants that were four months old listened longer to a Mozart minuet that was played as written than an unnatural version. In the unnatural version pauses lasting two beats were inserted away from the natural phrase boundaries (refer to Appendix I). The results of the study support the theory of Dr. Xiaodan Leng and Dr. Gordon Shaw on higher brain function, which proposed that the neural language of the cortex consists of specific natural sequence (Shaw 356). The researchers believed that the characteristics of Mozart's music exemplified the neural language (Shaw 261).

The basic building blocks of laboratory music are rhythm and tempo. Infants who are as young as seven to nine months old mentally group sound sequences into meaningful "chunks" the same way adults do (Jensen 25). Infants of the same age also recognize the same melodies played at different tempos and respond quickly to any rhythm changes. At five months infants can hear and react to the differences between two notes in a musical scale (Weinberger, The Musical 1-2).

Researchers tested college students, six-year-old children and six to nine-month-old infants to distinguish how each group processed consonant and dissonant tonal intervals. Each group processed the consonant tonal intervals better than the dissonant intervals. The objective of the research was to prove the biological origin for consonance (Jensen 21). The infants responded with smiles to the pleasing sounds and with displeasure for the more unstable dissonant sounds. Even though musical knowledge is experience-dependent, most nonmusical individuals are able to make distinctions in musical tones. The ability to discern musical tones and dissonant music occurs before any form of musical training. In the words of Sandra Trehub, a psychologist at the University of Toronto, "Musical preferences are not shaped by culture alone but wired into our brain from birth" (Begley 1-6).

Infants could understand and remember melody and recognize changes in pitch. Increases and decreases in pitch are called "contours of the melody". When music was played for the infants with only a change of one note, the infants would look at the loudspeaker (Jensen 21-25). Through ordinary observation one realizes that an infant responds to changes in pitch. When very young infants are spoken to in a high-pitched voice, they become more alert; not because they understand the words spoken, but because they detect a change in pitch. Infants learn to detect differences in melodies before speaking.

A review of the research on prenatal and postnatal music exposure revealed the infant's complex ability to perceive, process and understand the components of music. The musical recognition in an infant begins in the last trimester of pregnancy (Jensen 24). Infants remember music heard before birth and react when the same music is played after birth. An infant learns and memory develops by responding to various musical stimuli. Music can be used as a learning tool in early ages. An infant reacts to unnatural versions of music. Infants can distinguish between two different pitches, (Weinberger, The Musical 1-2) detect rhythmical changes, recognize a melodic contour, organize music into "chunks," and react to the difference between consonant and dissonant musical passages (Jensen 21-25). The infant's perception and cognition of the basic elements parallel the manner in which adults listen to and process music. Research offers conclusive evidence that music stimulates the infant's brain and increases the neural connections for brain development. The brain of the infant appears to be wired for music (Begley 1-6).

Rising interest from the educational and scientific communities may produce the relevant research needed on the values of music in the prenatal and postnatal stages. Researchers agree that one must use caution when introducing any stimuli to the fetus; however, there are no studies that show any adverse effects of music on the infant. Dr. Gordon Shaw, a physicist at the University of California in Irvine, who currently conducts research projects at the Mind Intelligence Neural Development Institute, warns against playing continuous music stimuli for the fetus. After ten years of ultrasound technology research, Heinz Prechtl concluded that fetal movement develops according to set patterns. Over-stimulation of the fetal auditory system could result in altering the sequence of movement development (Shaw 256).

Over the last twenty-five years, Dr. Gordon Shaw and various colleagues conducted scientific research on brain activity and mental processes (Shaw xiii). In 1991 Dr. Shaw and Dr. Xiaodon Ling developed a trion model of the cortex and hypothesized a casual connection between musical training and spatial-temporal reasoning. The researchers developed a theory based on Mountcastle's columnar organization principle of the cortex in pattern recognition (Shaw 160). In 1992, to test this hypothesis, Dr. Shaw and Dr. Frances Rauscher, of the University of Wisconsin at Oshkosh, began research on the casual relationship between musical training and the development of the neural circuitry, which controls spatial reasoning ability. Three-year-old students from an inner city daycare center and a school for the arts comprised the first pilot study. Inner city children received thirty minutes of group singing each day and arts school children received fifteen minutes of private piano keyboard lessons. After six months the children in both groups tested higher than the norm in spatial-temporal reasoning on the Wechsler

Preschool and Primary Scale of Intelligence-Revised Test (Wechsler). Testing involved placing puzzle pieces together to match an image (refer to Appendix II). The inner city group improved the most by ninety-one percent (refer to Appendix III). Preschool children with music training displayed improved spatial reasoning ability in the pilot study (Rauscher, Music and Spatial: A Casual). Spatial-temporal reasoning skills involved the ability to form mental images from physical objects or to visualize patterns in space and time. A person putting a puzzle together uses these skills to envision the picture the pieces will form. A chess player uses these skills to anticipate and respond to an opponent's move. An architect uses the skills to design a structure. Such skills assist a person in understanding proportions, geometry and various mathematic and scientific concepts (Shaw 159-163).

Next, Rauscher and Shaw decided to test the effects of short-term music exposure on spatial-temporal reasoning. Researchers selected *Mozart's Sonata for Two Pianos in D Major (K.448)* because of the organization and complexity of the composition. The researchers thought the structure of the piece, with a limited number of musical motives presented in symmetry numerous times, aided the cognitive processing in the brain. Thirty-six college students participated in three different ten-minute listening sessions consisting of: the *Mozart Sonata,* a relaxation tape and silence. After each listening session the students completed one of three spatial tasks from the Stanford-Binet Intelligence Test, (Thordike) which included: paper folding and cutting, pattern analysis and matrices (refer to Appendix IV). The results showed that after listening to Mozart the spatial reasoning scores were significantly higher (refer to Appendix V). The Mozart group had a mean standard score of 57.56, the relaxation group's mean score was 54.61 and the mean score of the silent group was 54.00. Mozart group scores reflected an eight to nine point increase. The enhanced effect lasted only ten to fifteen minutes. Pulse rates of the Mozart group remained unchanged before and after the listening session, discounting arousal as a cause for the student's improved test results. (Rauscher, Music and Spatial).

In 1994, Dr. Shaw and Dr. Rauscher conducted an experiment to confirm the findings of the first study with seventy-nine college students from the University of Irvine in California. On the first day, the students completed sixteen paper folding and cutting tasks. The researchers assessed the pre-test sources and divided the students into three matched groups. The second day, the students completed three sets of standard intelligence spatial reasoning tasks: a pattern analysis test, a multiple-choice matrices test and a multiple-choice reasoning test. A ten-minute controlled listening period preceded each task. The first group listened to ten minutes of *Mozart's Sonata for Two Pianos in D Major (K 448.)* The second group listened to ten minutes of silence. Rauscher and Shaw expanded the study and included mixed group listening in the third group that consisted of an audio taped story, a highly rhythmic dance piece and a minimalist composition by Phillip Glass. The musical pieces were repetitive with long pauses between notes, unlike the complex and richly patterned compositions of Mozart. Following the controlled listening, researchers tested the students' spatial reasoning skills using the Stanford-Binet Intelligence Scale. The Mozart group's score from day one to day two exceeded the silence and mixed group scores on spatial-temporal reasoning. (refer to Appendix VI). As indicted in the previous study the enhanced performance of the Mozart group lasted only ten to fifteen minutes. The researchers concluded that specific music primed the brain to perform spatial reasoning tasks. Rauscher and Shaw theorized that the simplicity of the repetitive music in the mixed group listening sessions impeded abstract reasoning. After the second day of the five-day experiment, a ceiling effect in the Mozart group occurred. A significant number of the Mozart students were correctly performing fifteen and sixteen of the sixteen, paper cutting and folding tasks. Thus, an advance in statistics could not be evaluated. The test scores of the group that sat in silence improved over the course of the five-day experiment but did not exceed the best scores of the Mozart group. Rauscher and Shaw attributed the improvement of the silence group to the practice provided by each day's experiment or the learning curve. (Rauscher Listening).

Dr. Shaw and Dr. Rauscher conducted a two-year study in 1994 to determine if musical training could produce long-term enhancement of cortical firing patterns used in spatial temporal reasoning. For the test, researchers divided seventy-eight ethnically diverse California preschool children into four groups. Group one received ten-minute piano lessons each week. The second group participated in thirty-minute singing lessons, five days a week. The third group experienced ten minutes of computer training each week. The fourth group received no training. Pre-testing and post-testing of students included the use of the Wechsler Preschool and Primary Scale Intelligence-Revised Task Test and found to be in the normal intelligence range. The WPPSI-R task tests measured various spatial abilities when given at the start of the study and again six to eight months later. Although the four groups of children's pre-test scores showed no differences the post-test scores differed. The children with piano training performed thirty-four percent higher on a puzzle test with a forty-six percent increase in spatial IQ (refer to Appendix VII).

The study indicated that piano lessons produced lasting changes in higher brain functions. In order to play the piano, children must think ahead in patterns. The visual-linear representation of the spatial relationship between pitches on the keyboard helps the student learn intervallic relationships. Visual and aural processes of piano playing promoted neural pattern development associated with spatial temporal tasks. The students see the keyboard and spatially link touch with sound. Although this does not teach children mathematics or engineering at an early age, Dr. Shaw states, "The music is tapping into the same inherent structure in the brain that will be later used for tasks such as mathematics, science, architecture, engineering, and chess." The researchers concluded from the study that musical training generated the neural connections used for abstract reasoning (Rauscher, Music Training).

In an effort to rule out language biases or cultural pressures that can alter human studies, Dr. Rauscher released a study in 1998 examining the effect of rats listening to music. Each day one group of rats listened to twelve hours of the *Mozart Sonata (K.448)* through audio conditioning. Exposure began three weeks before birth and ended sixty days after birth. The rats in the Mozart group ran through the mazes with fewer errors than the control group of rats in the study (refer to Appendix VIII). The three control groups of rats listened to one of the following: repetitive type music, silence or white noise. Four hours after the listening session each group of rats completed a test on performance in moving through a spatial maze. The Mozart rats ran through the maze faster, with fewer mistakes and improved each day (refer to Appendix IX). The findings of the research implied that early exposure to music listening accelerated perceptual-motor changes in rats for at least four hours. In a continuing effort to understand the neurophysiological basis for the Mozart effect, Rauscher is currently conducting histological studies to locate the neural processes involved in the enhancement of brain function in the Mozart rats (Rauscher, Improved Maze).

The research studies of Rauscher and Shaw, investigating the benefits of music listening and music training on spatial-temporal reasoning, support music as an essential discipline in learning. In general, a few minutes of enhanced spatial reasoning linked to specific music listening would not be important in a student's education. The importance of the findings lies in discerning how brief exposure to a particular piece of music relates to cognition and brain function. Linking music listening to spatial-temporal reasoning explores the possibility of transfer of musical processing to other reasoning abilities. In the studies where preschool students received piano instruction an improvement in spatial tasks proved to be more long term, lasting at least three days. Researchers theorized that the structured neuronal firing patterns evoked by music strengthen the same patterns used for the spatial-temporal skills of math. In the cross-species studies with rats the Mozart effect occurs, ruling out a cultural or psychological cause for the enhancement. Rauscher and Shaw concluded that early exposure to music training could develop neural connections that are necessary for understanding math and science concepts.

The research of Rauscher and Shaw, in regard to the Mozart effect (Rauscher, Music and Spatial), generated disagreement and misconception between educators and scientific researchers (Chabris 826-827). Many music educators question the relevance of the studies to music education, (MENC 33-59), and many scientific researchers have been unable to replicate the same results of the studies (Steele 366-369). Both the mass media and the author/musician, Don Campbell, have published the results of the Mozart effect. The contents of the publications left the general public with the simplistic view that improved intelligence could be obtained by purchasing a classical piece of music (Conrad 1-6). Books by Don Campbell entitled "The Mozart Effect" and "The Mozart Effect for Children" have sold the most copies on the subject to date at four-hundred thousand. Campbell's Mozart compact disc series ranks in the top fifteen best selling classical recordings for the present year (Conrad 4).

Dr. Norman M. Weinberger is the director of the Music and Science Information Computer Archive. The organization publishes a newsletter on the latest scientific research relating to music. Weinberger states that "The books by Don Capmbell are inaccurate and reign with distorted explanations of beneficial effects of music by the "Mozart Effect" (Weinberger, Matters 12).

As a result of all the national attention devoted to what is now commonly called the "Mozart Effect," former Democratic Governor, Zell Miller, of Georgia, initiated a program that distributed free classical music compact discs or tapes to all parents of newborns (Prokhorov 14). In Florida the "Beethoven Babies Bill" supported that early child care facilities expose children to classical music at least thirty minutes a day. Both programs provide language and music enrichment to promote healthy brain development (Gallia 1). The well-intended media attention has oversimplified the "Mozart Effect," and many people now view classical music as a listening experience that increases general intelligence.

In the September 2000 issue of Music Educators Journal, Steven Demorest and Steven Morrison objected to evaluation methods of Rauscher's 1995 study (Demorest 33-58). The Mozart group's improvement was attributed to listening to Mozart and the silence group's improvement correlated to the learning curve. The music educators concluded that the study was narrow in scope because the improvement only applied to spatial-temporal reasoning and resulted in short-term effects. In regard to the keyboard research studies by Rauscher, (Rauscher, Classroom) the educators pointed out again that the only improvement was in spatial-temporal reasoning. Demorest and Morrison believe that general music must encompass more than a few minutes a week of keyboard training and group singing (Demorest 35-36). The educators did not address the importance of music to the general development of the children. Demorest and Morrison support new research from the scientific community focused more on music theory and practice. Most music educators believe that music is a basic subject in the educational experience and are supportive of recent neurological research that a musical brain is innate to all humans (Demorest 38-39).

Some studies failed to duplicate the statistical results of the original Mozart effect findings and challenged the idea that listening to music can enhance intelligence. In a 1999 *Nature* journal article entitled, "Prelude or Requiem for the 'Mozart Effect,'" Christopher Chabris of Harvard University in Massachusetts, Kenneth Steele of Appalachia State University in North Carolina, and two Canadian universities, the University of Montreal and the University of Western Ontario, released negative results in replicating the Mozart effect. Chabris conducted a qualitative analysis of sixteen studies involving seven hundred and fourteen people. The results of the analysis revealed that any increase in intelligence after listening to classical music was statistically insignificant. Chabris concluded that listening to Mozart only enhanced learning in specific tasks that involved visualizing the results of folding and cutting paper. Rauscher, the leading researcher in the original experiment argued that Chabris included abstract reasoning tasks that did not measure spatial-temporal task abilities. Chabris suggested that the enhanced performance occurred only if the participants enjoyed the stimuli. A study of just over eight thousand British school students affirmed improvement on paper folding and cutting tasks after the students listened to popular music that was audibly pleasing. Another study confirmed that listening to a Stephen King story enhanced the scores on paper folding and cutting tasks for study participants who favored the author's writings. (Chabris 826-827).

Rauscher cited the rat studies as evidence to discount Chabris' assumption that preference for particular stimuli was the determining factor in the enhanced scores. The rat studies supported a neurological basis for the effect of

Mozart music on higher brain function (Rauscher, Improved). The combined research findings of Steele, the University of Montreal and the University of Western Ontario failed to replicate the Rauscher original Mozart research. Although included in Steele's study research, the paper folding and cutting tasks, had no positive effects in the experimental group (Steele 366-369). Rauscher replied in the same British *Nature* journal report that the design elements of the three combined research studies did not replicate the original study. Rauscher further stated, "Because some people cannot get bread to rise does not negate the existence of a 'yeast effect'" (Chabris 827-828). Rauscher's examination of the participants in Steele's research revealed that the beginning abilities of Steele's subjects were equal to the improved performance of the subjects in the original test. Rauscher concluded that the subjects' performance before the test was already at the maximum ability level of the subjects.

Kristen Nantis replicated the Mozart effect in a 1999 study, but only in participants who preferred the Mozart music to other forms of stimuli. The researcher concluded that mood and arousal were important factors in the enhanced performance; (Nantais 370-373) however, Rauscher discovered that the participants in the Nantis research who listened to Mozart had improved test scores even where the same participants preferred a Mendelssohn piece of music to the Mozart piece of music (Weinberger 9). This fact would seem to discount the mood and arousal conclusions. Also, if mood was the condition that caused the enhanced effect, the effect should have enhanced more than just one of the tasks presented in the test. The question remains, why does the Mozart effect enhance only spatial-temporal reasoning tasks (Chabris 826-827).

The failure of some researchers to reproduce the Mozart effect results of Rauscher and Shaw's studies challenges the validity of the studies. Systematic analysis of musical effects of learning warranted future neurological and educational research. New research following the experimental design of the original Rauscher and Shaw studies may answer the scientific controversy.

I conducted an object assembly task test and a pattern completion task test to study the effect of music on spatial reasoning tasks. Thirty students, ages six and seven, from two first grade elementary classes participated in the study. The students were pre-tested for academic placement in classes by the school at the beginning of the year. The school divided each class equally according to test results. There were eighteen males and twelve females tested. Each class consisted of nine males and six females. Most of the students were in middle class socioeconomic families. The object assessment task test contained eight shapes that when correctly placed on the handout create an image of a lobster. The pattern completion task test consisted of four separate dot-to-dot pattern lines to complete the given pattern. Each class had completed both forms of spatial tasks in previous classroom exercises.

The Mozart group had five students who will be recommended for the gifted and talented program in the upcoming school year, one student with a speech impairment, and one with ODD (Oppositional Defiance Disorder). The control group contained seven gifted and talented students and no learning disabled students. Each class consisted of two students who had some type of formal music training.

The Mozart group listened to six minutes of *Mozart's Sonata in D Major (K.448)* prior to the spatial reasoning task tests. This was an extremely active class, but they were all quiet and attentive during the listening exercise. Even the ODD student sat quietly. After the students listened to the Mozart piece, an object-assembly task test was distributed. The class had three minutes to place the shapes in the appropriate spots on the test (refer to

Appendix x). All of the students completed the task with one hundred percent accuracy (refer to Appendix XI). A pattern-completion test followed (refer to Appendix XII). Students had five minutes to finish the test. The class correctly completed sixty-five percent of the patterns (refer to Appendix XIII).

The control group listened to two minutes of recorded sound effects and four minutes of Simple and Easy, by Amy and David Stoner, prior to testing. This class was not as attentive during instruction and was very talkative. After the listening exercise, the students were given three minutes to complete the object assembly task test (refer to Appendix X). All of the students completed the task with one hundred percent accuracy (refer to Appendix XI). The students then were given five minutes to work on the pattern completion test (refer to Appendix XII). The class correctly completed thirty percent of the patterns (refer to Appendix XIII).

Both classes were equally active during the previous teaching instruction of general music. Each class was eager to learn, but also loved to talk. The Mozart group was more focused and stayed on task better than the control group.

The classes scored the same on the object assembly task test. On the pattern-completion task test, the Mozart group scored thirty-three percent or twenty points higher than the control group. The results of the test reflected that the group that listened to Mozart scored significantly higher on the spatial reasoning test. I believe that music is an integral part of education. The results of this group study are promising. It would be interesting to repeat the listening to *Mozart's Sonata in D Major (K.448)* to see if repeated listening could give a greater increase in spatial reasoning task tests over a longer period of time. I chose to conduct my own study of this kind based on the controversy apparent in recent research.

Interest in the "Mozart Effect" primarily focuses on improvements of intelligence for one task, spatial-temporal reasoning, and for only a temporary span of time. The World Book Dictionary defines cognition as a process that relates to an act of acquiring knowledge. How important could ten minutes of increased cognitive skills be to learning? The answer lies in the evidence that music affects brain function in some way that produces transfer of cognition to other disciplines. Contrary to popular belief, there seems to be no identifiable brain structure that works exclusively for music cognition (Lemonick 1-3).

Through the modern technology of neuroimaging, new studies concur that musical responses stimulate many areas in the brain, including regions normally involved in other forms of thinking (Shaw 53-72). Educators and researchers continue to debate the transfer of music learning to other disciplines. The American Psychological Association cites almost seven thousand cases of transferred learning (Weinberger 6).

Does current research in this field support the theory of musical transfer to the areas of language and reading skills, spatial and temporal tasks, verbal and quantitative abilities and memory? In "Keeping Mozart in Mind" author Gordon L. Shaw states, "Music is a window to higher brain function" (Shaw xiii). Research seems to point to the fact that music conditions the brain for learning, and that the brain can transfer the mental skills developed in music to other areas that require some of the same skills (Winner 1-11).

The long-term effects of music listening may prove to have more lasting effects on learning. There are two ways to listen to music, passively and actively. If one simply listens to music, passive involvement takes place; but if one listens through the formal teaching of music appreciation, active involvement occurs. Although many people believe that there are strict lines between music and cognitive processes, the making of music and active listening both require cognitive processes (Jacobson 1-5). An example would be score reading. Score reading involves correctly perceiving the score; understanding the meaning of dots and lines on the page; remembering music demands and markings, transforming written commands; listening to results; the repeating and practicing of the process. If something as simple as listening to music has positive cognitive transfer, more active involvement might reap greater rewards.

Around 1945, Zoltan Kodaly, a Hungarian music educator, developed a method for teaching music that was later adopted by the Hungarian school systems (Dickinson 1-4). An academic achievement for the students in math and science in Hungary continues to surpass the students in the United States. The academic success of the Hungarian students correlated to the inclusion of the Kodaly Method of teaching music in the curriculum in kindergarten through twelfth grade. Children learned to use the innovative Kodaly method to sing on pitch and read music (Jensen 82). As early as 1975 studies correlated Kodaly training to improved reading performance in first grade students. An experimental group received forty-minutes of music instruction five days a week for seven months. A controlled group had no extra training, but the same teacher for classroom instruction. The reading ability of the students was tested before and after the musical training. Backgrounds and intelligence levels of the students were similar. On reading tests the Kodaly students scored in the eighty-eighth percentile. That was sixteen percentile points higher that the controlled group (Weinberger 1-4).

A later study in 1982 found that Kodaly singing instruction twice a week for three-year-old nursery school students improved motor development, abstract conceptual thinking, play improvisation, creativity and verbal skills. A correlation of musical benefits to the improved abilities was a result of the study. The lack of improvement by the control group might be attributed to the exclusion of any extra enrichment experiences (Weinberger 3).

In 1996, Martin F. Gardiner conducted studies at two public schools in Pawtucket, Rhode Island, that produced strong evidence that sequential, skill-building instruction with regular curriculum can improve children's performance in reading and math. Students in five first grade classrooms received music and art instruction typically found in schools across the country. Four first grade classrooms taught by the Kodaly method learned to sing songs that were sequenced by difficulty. The students also played rhythm and pitch games. At the end of the seven months, the students receiving spatial musical training were the same or slightly better in reading than the typical classroom. Math scores escalated above the typical classroom, even when the child began slightly behind the other students. Math concepts were improved eighteen percent (refer to Appendix XIV). At the end of two years, the Kodaly-trained students were still ahead in math. Improvements were evident in children entering at the bottom, middle and top of the class in terms of test scores. Gardiner believed that the boost in math scores occurred, in part, because music aids the understanding of concepts such as number lines. Gardiner also believed that although the "test arts" classes began behind the control students in the number of students at or above the national average of kindergarten Metropolitan Achievement Test scores, the students were either equal or pulled ahead in math in seven months (Gardiner, Learning 284).

In Gardiner's 1998 study, the math performance of the fourth and eighth grade students showed continued improvement. Gardiner developed a theory called mental stretching to explain the increase in performance.

Developing a mental skill in one area of learning that the brain can transfer to another area of learning that may require the same skill is mental stretching. Basically, Gardiner believes that other disciplines can benefit from skills learned in music (Gardiner, Arts 1-7). A tremendous number of complex variables may have an impact on the results of research with school students. However, positive results came from Shaw's Los Angeles math studies (Peterson) and Gardiner's Pawtucket studies conducted in low socioeconomic, inner city schools (Gardiner, Learning 284).

Another type of music program, Kindermusik, had been successful in improving learning in nursery school children. Kindermusik was developed in Germany and emphasizes various music and movement activities to introduce musical concepts to young children. Students play instruments, learn rhythm, dance and sing. A 1999 Kindermusik study exposed four and six -year- old students to seventy-five minutes of music for thirty weeks. Parents participated in some classes and reinforced the learned music abilities at home. Set criteria for the music curriculum measured the progress of the students. Students that learned the music curriculum scored higher on the Stanford-Binet subtest for abstract reasoning abilities than students who did not successfully learn the curriculum. The researchers recorded student and parent participation in the music program during the study. Records indicated that the students and parents with the least music participation scored in the fiftieth percentile. Students and parents with average music participation scored in the seventy-eighth percentile, and students and parents with the highest music participation scored in the eighty-seventh percentile. The abilities of the students to match vocal pitches and to reproduce rhythmic patterns correlated to better abstract reasoning abilities (Psychology 1-4).

Music can also improve the phonemic stage in the process of learning to read. This stage involves understanding the association of letters to the appropriate speech sounds. A 1993 study taught first grade students two separate learning skills: to phonetically sound out words and to determine pitch changes in musical notes. The study revealed that the students with better pitch discrimination read at a higher level. The findings correlated reading ability to the ability to hear the pitch of a note (Weinberger, Music 2).

In 1998, the results of the McGill University Piano Project, by Eugenia Costa-Giomi, found improved general cognitive abilities and spatial abilities for students that received three years of piano instruction. One hundred and seventeen participants of the study were from homes with an average income of thirty thousand dollars a year. The students had no previous formal musical instruction. For the first two years students received thirty-minute piano lessons at recess or after school, and in the third year the lesson time increased to forty-five minutes. The controlled group received no musical instruction. All of the students completed a test before the beginning of the study, and no difference in standardized test achievement for the age level existed. During the first two years the students with piano instruction improved in tests for pattern recognition and mental representation over the students in the control group. The third year of the study produced no increase for piano students or the control students. Costa- Giomi concluded that practice and dedication to learning music decreased in the third year, as the piano students entered preadolescence. The impact of missed lessons, minimal practice, and loss of interest in the third year for piano instruction possibly attributed to the lack of test improvements (Costa-Giomi 198-210).

The Third International Math and Science Study revealed that eighth graders in the United States ranked twenty-eighth in math, according to an evaluation of five hundred thousand students from forty-five countries (National.) Based on the positive results of the piano research with preschool children, Dr. Shaw developed an innovative program for math instruction called Music Spatial-Temporal Math. The program consisted of three parts: piano keyboard training, computer software math instruction and a math integration lesson. The musical training portion of the program taught the basic music concepts and skills used in playing the piano. Each week the second grade students participated in forty-five minute lessons divided into three parts: music theory, music listening and keyboard instruction. The music theory section included the studying musical composers, clapping note values and reading musical notations. During the listening section the second grade students received five minutes of audio stimuli from Mozart's Sonata (K.448). Individual and group keyboard instruction included the mastery of fifteen music sections by the second grade students.

Matthew Peterson developed the computer software for the new math program. The program is referred to as STAR, Spatial-Temporal Animation Reasoning, and uses a computer-animated penguin to lead the students through the math and science based software (refer to Appendix XV). Shaw concluded that music in the program helped the students understand proportions in math (refer to Appendix XVI). The piano training strengthened the students' spatial awareness and ability to think ahead, which are important for understanding math concepts (Peterson). Students received math integration lessons once a week for thirty-five minutes to incorporate the piano and computer math game into the standard math curriculum. The latest study involved second grade students at the 95th Street School in the Los Angeles United School District. After eight months of the new math program, the result was an increase on the national Stanford 9 math scores from the thirtieth percentile to the sixty-fifth percentile, and half of the students ranked in the top twentieth percentile nationally. An increase in scores for the second grade was comparable to the fourth grade scores (refer to Appendix XVII), (Peterson).

Dr. Rauscher consulted on a field experiment for the Kettle Moraine School District in Wales, Wisconsin. The study focused on the effects of piano keyboard instruction on spatial-temporal reasoning. Pre-testing consisted of students completing two spatial-temporal tasks and one pictorial memory task to determine the division of the sixty-two kindergarten students. The composition of each group reflected similar test scores. Half of the sixty-two kindergarten students received twenty minutes of keyboard lessons twice a week in groups of ten, and the other half of students received no instruction. After four months, tests revealed that the keyboard group scored forty-three percent higher on solving puzzles and fifty-three percent higher on block building skills than the groups with no music instruction. At the end of the eight months the keyboard students' scores improved even more. There was no difference in pictorial memory. The positive result of the study encouraged an expansion, and kindergarten through fifth participated in the keyboard lessons (Rauscher, Classroom).

College students who had musical training before the age of twelve may have an advantage in memorization skills. A recent study in 1998 by Agnes Chan published in *Nature*, tested verbal memory. The number of words female college students could verbally recite from a previously viewed list of words determined the results of the study. The students with histories of musical training before the age of twelve were able to recall more words. The evidence supported the assumption that early music training improved verbal memory. The findings are consistent with the opinion that musical training improves other cognitive abilities (Chan 128). Although not directly related to cognitive transfer, but relevant to changes in the brain due to early music training, was the 1994 neurological findings from 1994 by Gottfried Schlaug. Profound differences were found in the brain fibers of the corpus callosum of piano and string professional musicians compared to non-musicians. This bundle of fibers that connects the left and right hemispheres of the brain was larger in the musicians. If the musical training started before the age of seven the difference was greater (Jensen 27).

The following two reports are by far the largest conducted studies to date on the siginficance of art in education and the importance of music in the learning process. The "Champions of Change: The Impact of Arts on Learning" in 1999, (Champions 1-95) and the Project Zero's "Reviewing Education and Arts Projects" in 2000, (Winner 1-11) analyzed the role of arts in education and presented some conflicting views on the causal relationship of the arts to academic achievement. Both advocated inclusion of music in the curriculum of students.

General Electric and the John D. and Catherine T. MacArthur Foundation, with support from the Arts Education

Partnership and the President's Committee on the Arts and Humanities, funded the "Champions of Change" project. Although the report covers all arts education, music comprised a major portion. The report contained seven independently conducted studies and involved researchers from the University of California at Los Angeles, Stanford University, (Champions iv) Columbia University, Harvard University and the University of Connecticut (Champions v). Dr. James Catteral and colleagues from the University of Los Angeles analyzed statistical data on twenty-five thousand secondary students spanning a ten-year period to evaluate the effect of arts participation on academic achievement. Close examination of economic status of the students' families ruled out the assumption that students from higher socio-economic families have a greater advantage in arts participation (Champions 2-3). Results of the analysis stated that performance in the arts increased academic subject scores and standardized test scores. The low socio-economic students gain was larger in comparison to the gains of the high socio-economic students (Champions 7). Of particular interest to music educators, the analysis showed that participation in instrumental music increased scores on math tests. Improvements increased each year from the eighth grade through the twelfth grade (refer to Appendix XVIII). Researchers concluded that the length of time spent in instrumental music certainly correlated if not caused the improvement in math (Champions 9-13).

A second study analyzed the impact of arts education on academic achievement in thirty-seven high poverty schools in the Chicago area. The program, called the Chicago Arts Partnership in Education, or CAPE, initiated in 1992, serves as an interactive arts enrichment program supported by local artists and arts agencies (Champions 48). A 1998 published assessment of the six-year CAPE program compared the CAPE schools to other Chicago Public schools through analysis of fifty-two test scores. High poverty CAPE schools, where over seventy-five percent of the student body received free lunches, constituted fifty percent of the study (Champions 53). The Iowa Test of Basic Skills and the Illinois Goals Assessment Program were the standardized tests used for evaluation of third and sixth grade students (refer to Appendix XIX). The Illinois Goals Assessment Program evaluated the eighth and tenth grade students, and the Test of Achievement and Proficiency evaluated the ninth and eleventh grade students. In general, the CAPE schools' reading and math levels surpassed the schools in the area without the enrichment program. The length of time spent in the program produced the greatest difference for increased performance. Ninth grade students were one grade level ahead of corresponding ninth grade students not in the program (Champions 55).

"Champions of Change" a comprehensive, longitudinal report, concluded that the effects of arts education in schools on academic achievement were significant, especially among low socio-economic students. Research data reflected the success of arts students across the United States. Evidence of the findings reinforced the positive role of music in education and the importance of continued instrumental music instruction. (Champions 1-95).

Ellen Winner and Lois Hetland of the Harvard School of Education comprised the research team on the Project Zero report that was funded by the Bauman Family Foundation (Winner 1). The comprehensive study reviewed eleven thousand, four hundred and sixty-seven articles, books, theses, conference presentations, technical reports, unpublished papers and unpublished data. Material covered fifty years of research and analyzed one hundred and eighty-eight studies (Winner 2-3). Analysis produced evidence that certain art forms, such as music, were beneficial to thinking and to learning other disciplines.

Researchers acknowledged a correlation between arts and academic achievement.

The findings of Project Zero are important for music educators and researchers. Research analysis demonstrated connections between music experiences and improvement in specific cognitive skills (Winner 1-11). Forty-five reports concluded that spatial-temporal reasoning improved for students involved in music. Listening to specific kinds of music temporarily improved spatial-temporal reasoning skills in adults. Lois Hetlands and Ellen Winner found support for the "Mozart Effect" by reviewing all the known studies to date, which included one thousand and fourteen subjects. The findings were a direct contradiction to the earlier conclusions of Harvard University psychologist, Christopher Chabris. Hetlands and Winner suggested that a psychological and neurological link existed between music and spatial reasoning (Winner 3-4). Six studies in the Project Zero analysis supported music training as a cause for math improvement. Another, six studies supported the relevance of music training to achievement in reading ability. In general, other areas of the arts improved performance in the following: verbal skills, critical thinking, nonverbal reasoning and reading (Winner, 5.)

Winner and Hetland acknowledged the fact that schools with arts programs scored higher on standardized tests. The researchers concurred that schools with effective arts programs were more progressive in using student oriented learning and appealed to higher academic performance. Proof for a causal relationship needed more research from studies that compared the academically challenged student with the academically advanced in the same educational setting according to participation and non-participation in arts classes. The researchers cautioned that music instruction should be independently valued (Winner 6-8).

According to statistics obtained by the Music Educators National Conference, students in 2000 with coursework and experience in music performance scored fifty-five points higher on the verbal section of the SAT and thirty-eight points higher on the math section of the SAT than students with no coursework in music. Students with coursework in music appreciation scored sixty-one points higher on the verbal section of the SAT and forty-one points higher on the math portion of the SAT. The SAT scores increased even higher for students that had studied the arts for four or more years. Students increased ten to twenty points per year of music instruction in the 2000 score report. These statistics pointed to a direct correlation between better SAT scores and the length of time devoted to arts study. The results of the SAT scores gradually increased each year (SAT 1-2).

Positive results of these new studies on the correlation of music to enhanced intelligence have created new public support for arts education. The data from a 1994 Gallup Survey of American's attitudes relating to music revealed that ninety-three percent of the survey participants felt music is part of a well-rounded education. Eighty-eight percent thought music aided children's overall intellectual development; and eighty-five percent supported providing financial resources from the community for music programs (Mahlmann 1-7).

The reality is music education plays a small role in today's education. The majority of American schools require no arts instruction for graduation (Sommerfeld 1-2). Only fifty-three percent of American schools have full-time music teachers (Fast 1). Music is often the first program to be affected by a budget cut and remains on the fringes of most school curriculum. The majority of full-time music teachers are faced with teaching an average of four hundred and ninety-seven students each week, a difficult responsibility for one educator. In Denver the ratio is one certified teacher to seven hundred students, in New Orleans and Boston the ratio is one to eight hundred, and in the elementary schools of Los Angeles the ratio is one to four thousand and five hundred (Mahlmann 6). In 1997 the first arts assessment in twenty years was published. The National Assessment of Education Progress Arts Report Card surveyed the achievement and involvement of students in arts programs. The report confirmed that music improved students' academic achievement. Music encourages creativity and individuality, allows self-expression and provides artistic pleasure. Music is a part of culture that helps children learn and should be fundamental to the education system (Student 1-5).

As America strives to rise above other nations in math and science scores, the benefits of music education should be carefully considered. Research reveals a correlation between exposure to music and rising test scores in areas such as spatial reasoning, reading and math. Such evidence should encourage current educational systems to promote music as an integral part of the educational curriculum. Members of the Music Educators Conference assisted in drafting a National Standards for Arts Education in response to the 2000: Educate America Act, passed by Congress in 1994. Music standards included nine basic areas of music education: singing; playing instruments; improvising; composing and arranging; reading and notation; listening; analyzing and describing; evaluating music and performance; understanding musical and artistic relationships and understanding music in relation to history and culture. The purpose of the act was to establish national educational goals in each educational discipline. Educational goals serve as a model not a requirement for state and local educational systems (Ganus 3). A second part of the act offered funding for program improvement to state educational systems. The next assessment in 2007 should reflect the direction of music education in the twenty-first century (Student 1).

The past decade has brought to the twenty-first century multi-disciplinary research focusing on the benefits of music on learning. Research confirms that musical experiences affect brain development beginning in the prenatal stages of life and continuing into adulthood. The infant's ability to perceive, process and understand the components of music expands the neural connections of the young, pliable brain. Current research reveals correlational and causal evidence for the improvement of cognitive skills after musical listening and training. Listening to a specific piece of music primes the brain for short-term learning of spatial reasoning tasks, while musical training enhances spatial reasoning. Analysis of numerous research studies reveals that the greatest benefit from music derives from active participation. Standardized testing scores indicate that students exposed to music instruction exhibit greater flexibility in math and reading. With surmounting pressure for improved student achievement scores, educators should acknowledge studies involving the effect of music on academic success and test performance. My independent research findings support the short-term effects of improved spatial abilities after listening to a complex Mozart composition. I fully support continued neurological and educational research on the effects of music on learning. I would support educational research studies that reflect behavioral data from long-term involvement in musical instruction. I further advocate neurological studies that utilize neuroimaging devices to map the brain while listening to, analyzing and playing music. The information derived from such studies could help to explain the transfer of mental skills developed in music to other cognitive domains. Lastly, I would support educational studies that compare the strong academic student to the weak academic student in the same learning setting, with and without music involvement.

After an extensive review of the effects of music learning, I conclude that the benefits of music transcend aesthetic value. Exposure to music does positively and directly promote the development of intelligence, academic achievement and organized cognition. Music should be a part of a well-rounded education.

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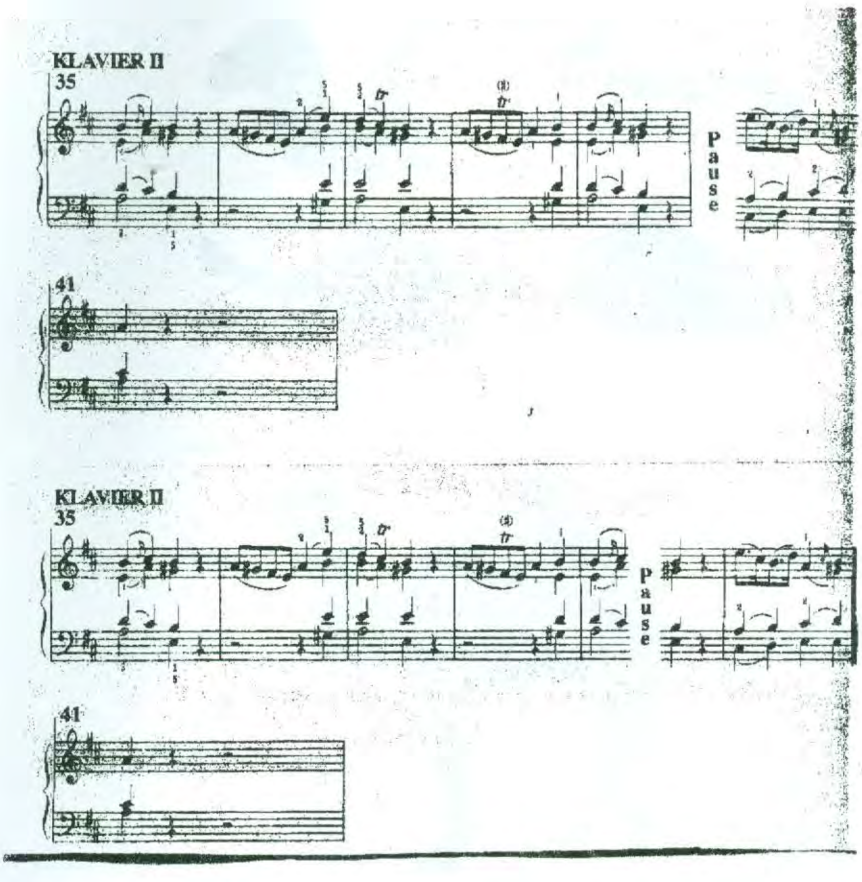
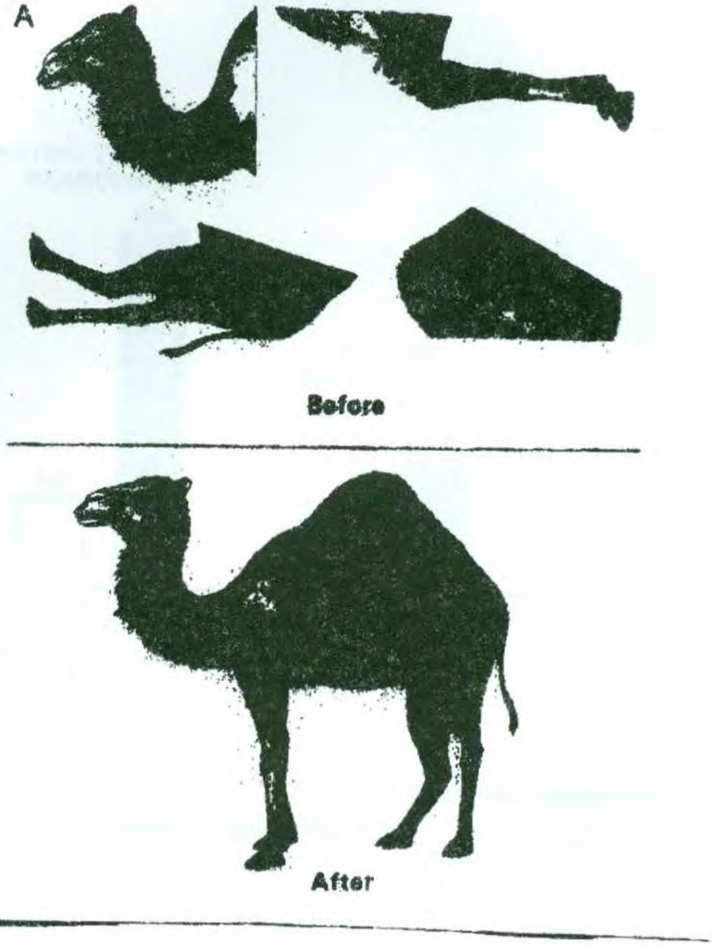
Appendix I



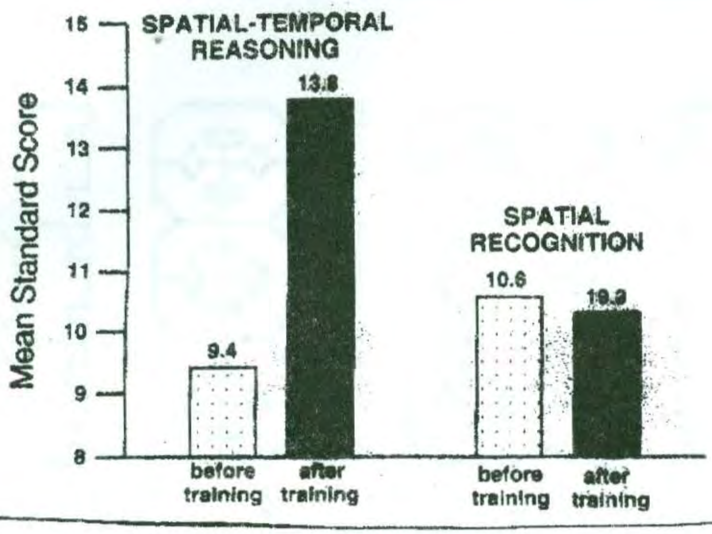
The top score is the natural version of a Mozart minuet with a pause inserted at a natural boundary. The bottom score is an unnatural version of the same piece with a pause placed away from the natural boundary. Source. Shaw, Gordon L. Keeping Mozart in Mind: San Diego: Academic Press, 1999

Appendix II



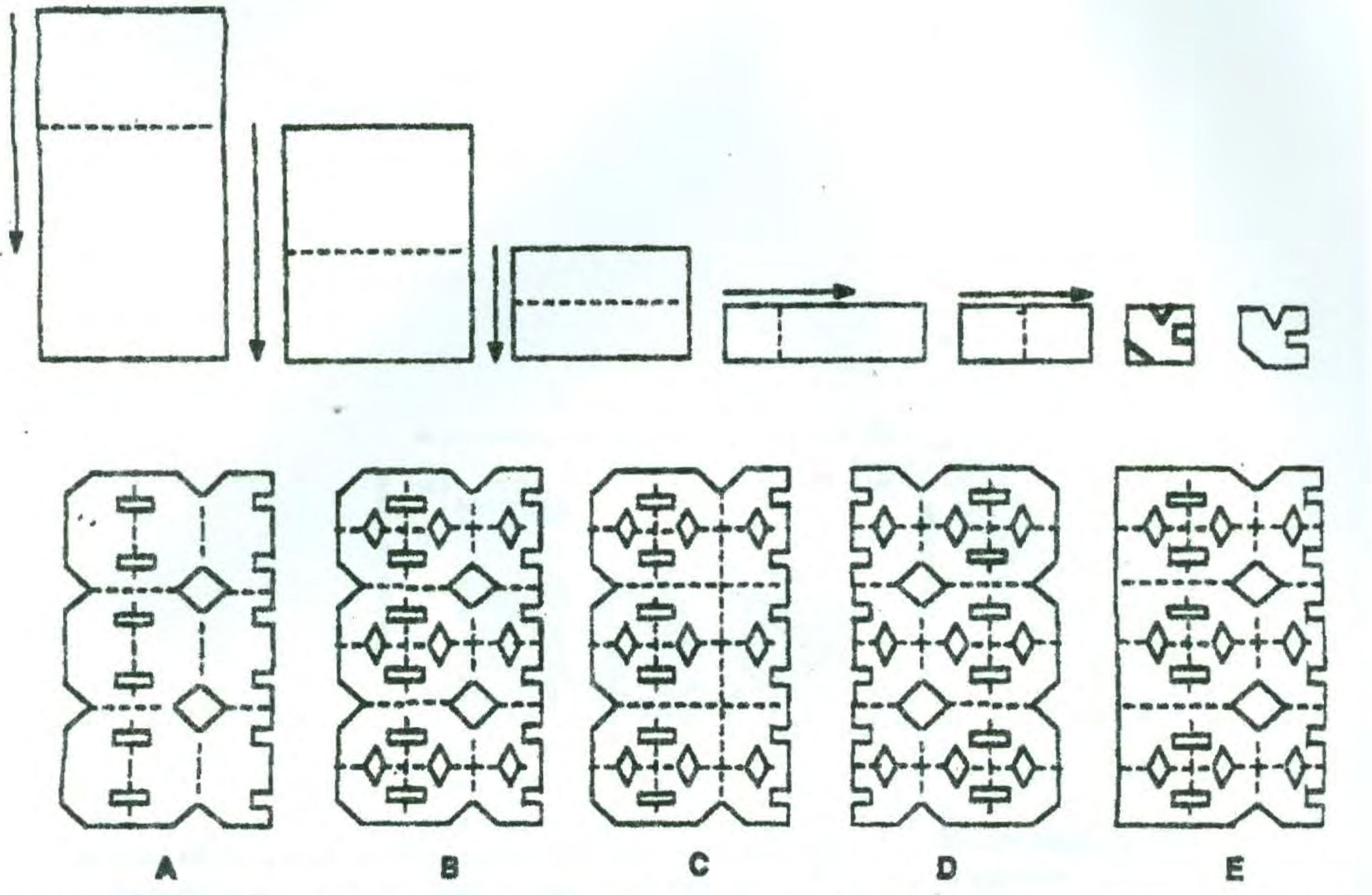
Object Assembly Task requiring spatial-temporal reasoning. Source. Shaw, Gordon L. Keeping Mozart in Mind: San Diego: Academic Press, 1999.

Appendix III



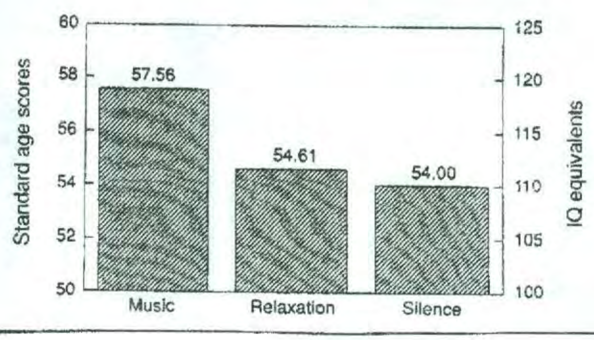
Inner city preschoolers' spatial-temporal reasoning improvement statistics after receiving thirty minutes of group singing each day. Source. Shaw, Gordon L. Keeping Mozart in Mind: San Diego: Academic Press, 1999.

Appendix IV



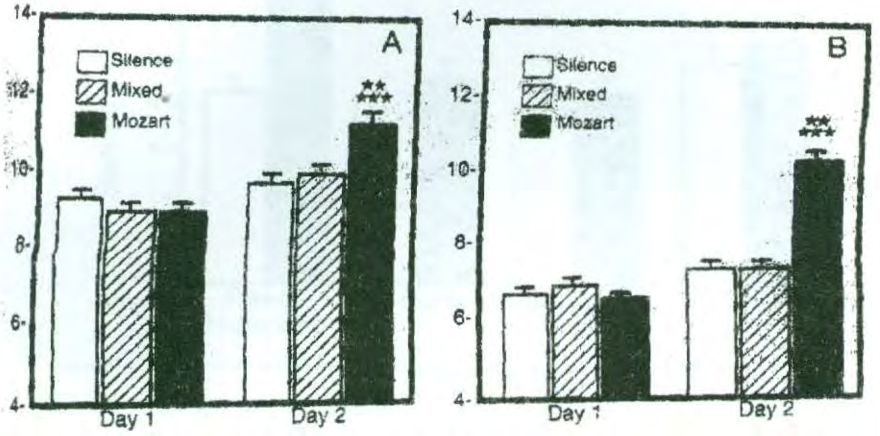
Example of a sequential item used in the paper folding and cutting task to test spatial-reasoning in the Mozart effect study. The objective of the task is to select the illustration in the bottom row that represents the appearance of the paper when it is unfolded. Source. Shaw, Gordon L. Keeping Mozart in Mind: San Diego: Academic Press, 1999.

Appendix V



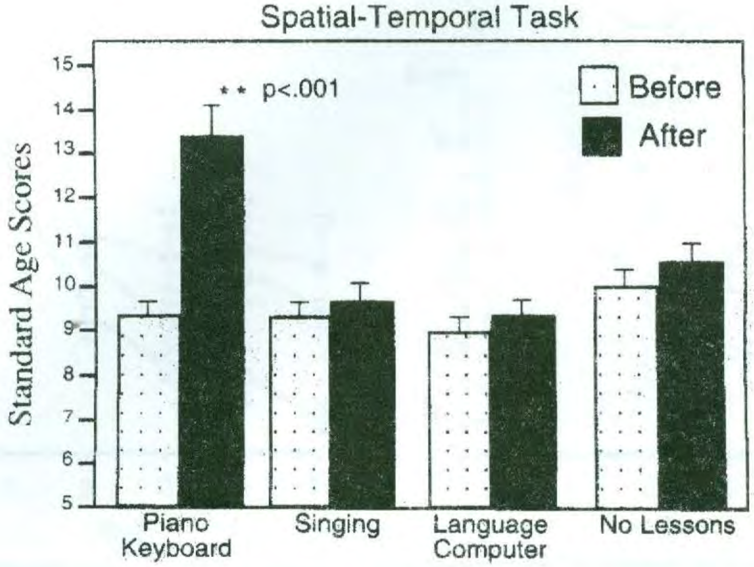
Results of the paper folding and cutting, pattern analysis and matrices tasks by the college students after the three listening conditions. Source. Rauscher *et al.* (1998)

Appendix VI



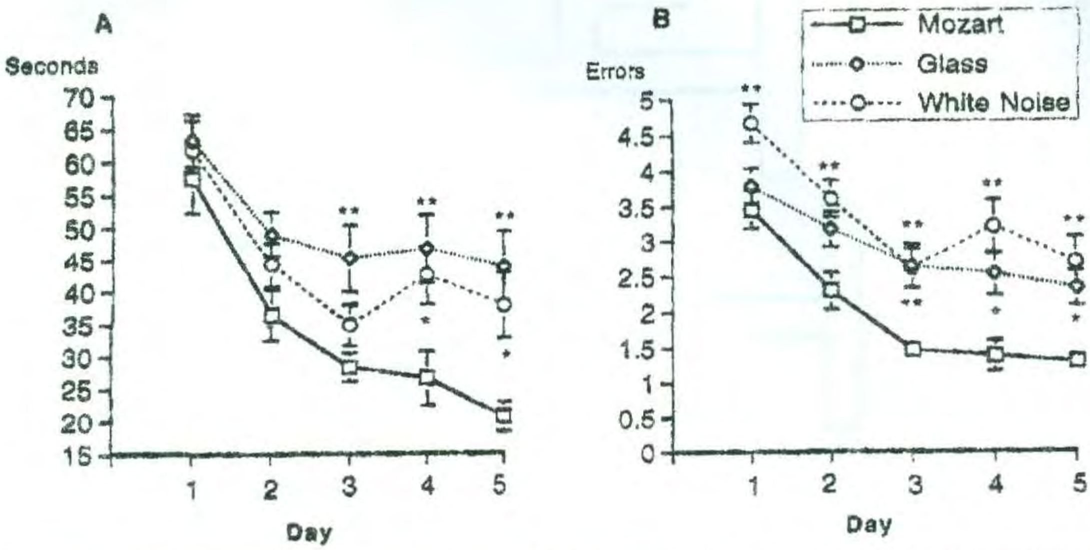
Day one shows the correct number of paper folding and cutting tasks performed correctly on the pre-test. Day two shows the correct number of paper folding and cutting tasks performed correctly after the listening exercises. The greatest improvement is evident in the second statistical chart. The Mozart students answering only eight questions on the pre-test improved sixty-two percent on the second day. Source. Rauscher *et al.* (1995)

Appendix VII



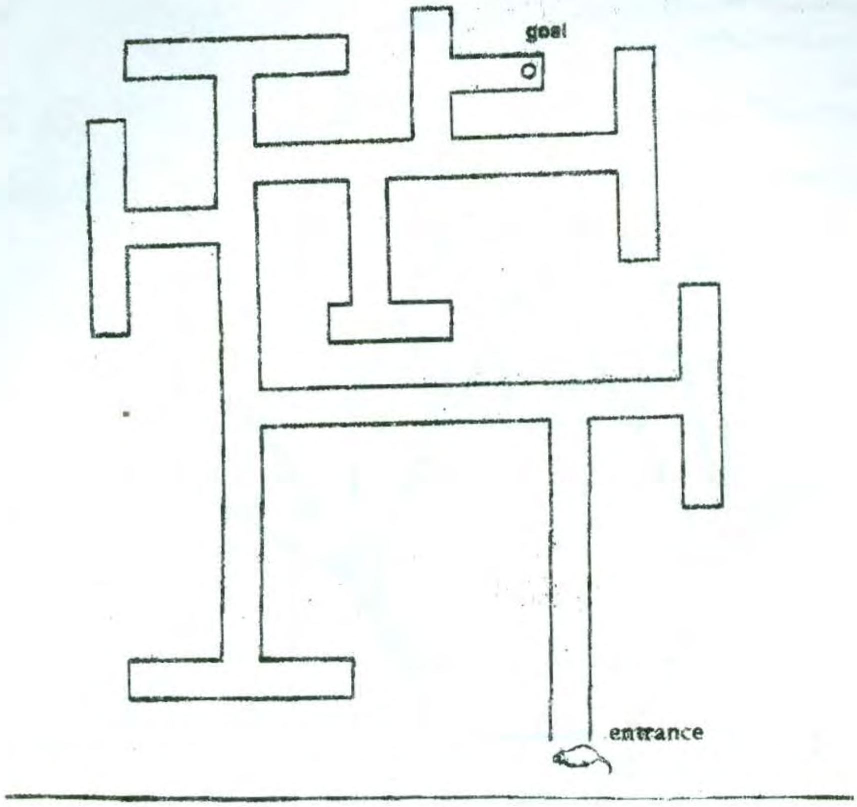
The chart shows how the four different types of training affects spatial-temporal task abilities by illustrating the before and after training Object Assembly mean scores. Source. Rauscher *et al.* (1997)

Appendix VIII



The charts show the amount of time and the errors of the three rat groups in the maze experiment. The Mozart rats performed better than the other groups on the spatial-temporal tasks of the maze over the five-day period. Source. Rauscher *et al.* (1998)

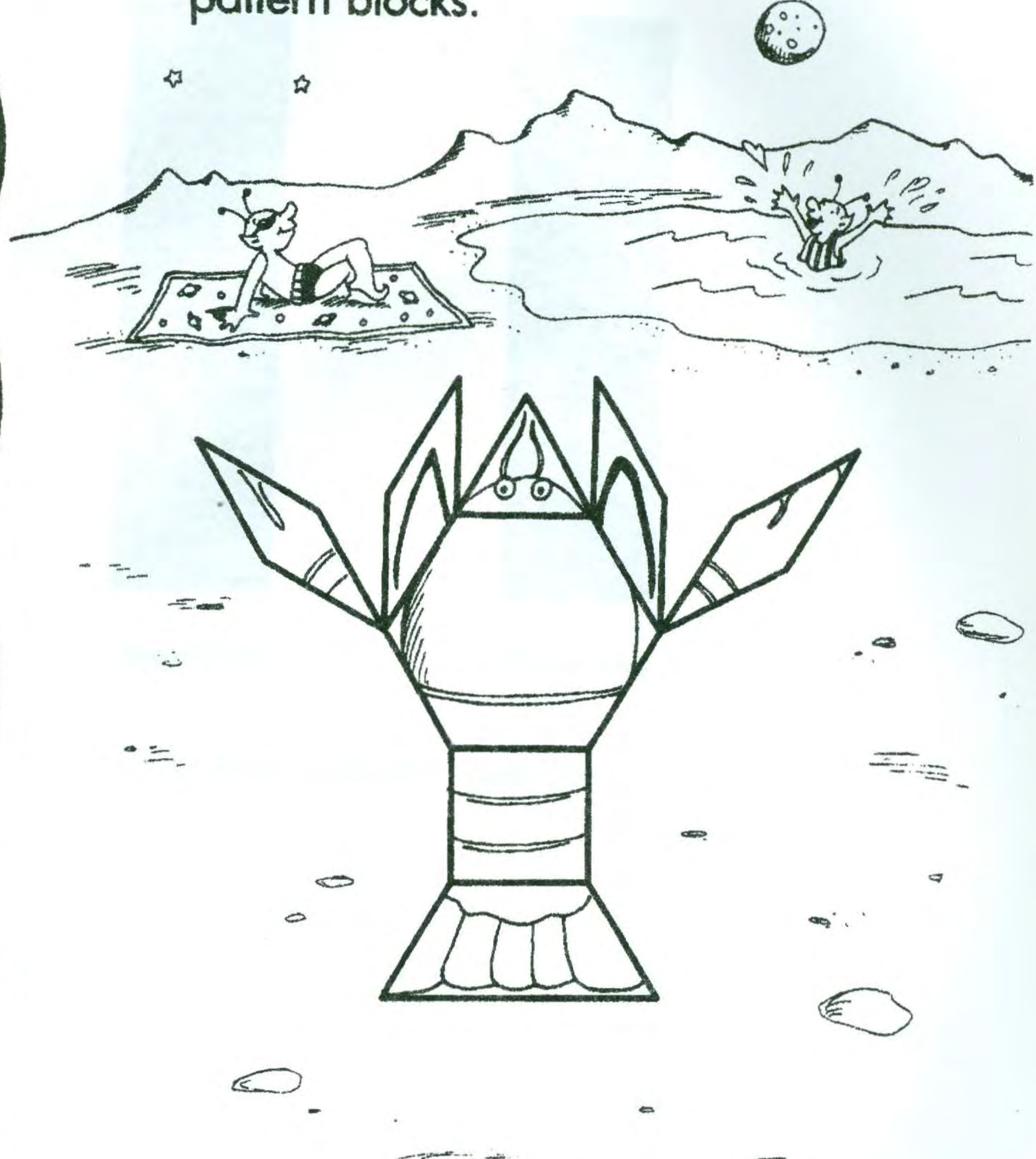
Appendix IX



Example of the spatial maze used in the rat study by Rauscher. Source. Rauscher *et al.* (1998)

Appendix X

Make the Space Creature using your pattern blocks.



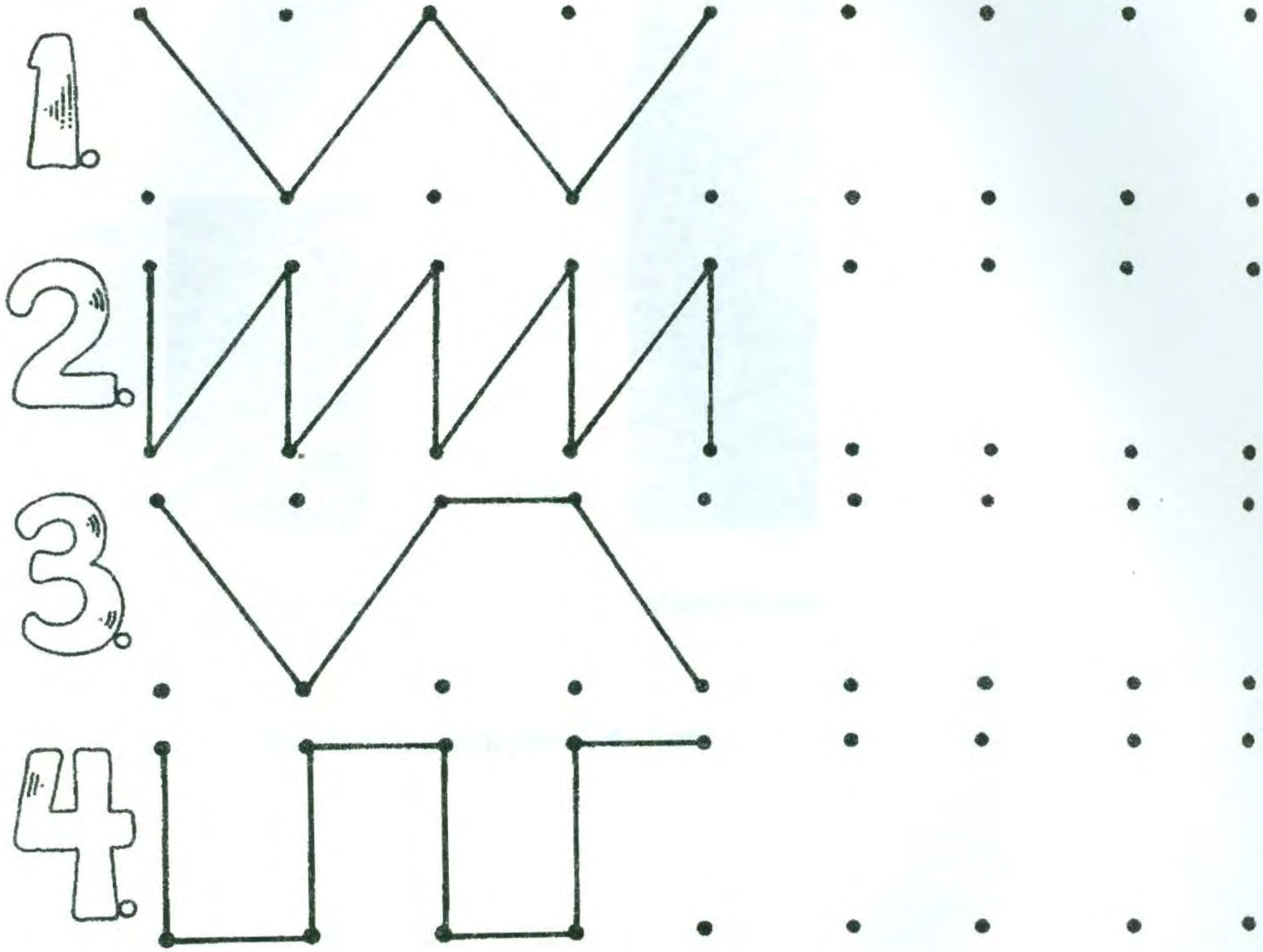
Appendix XI

Object-Assembly Task Test

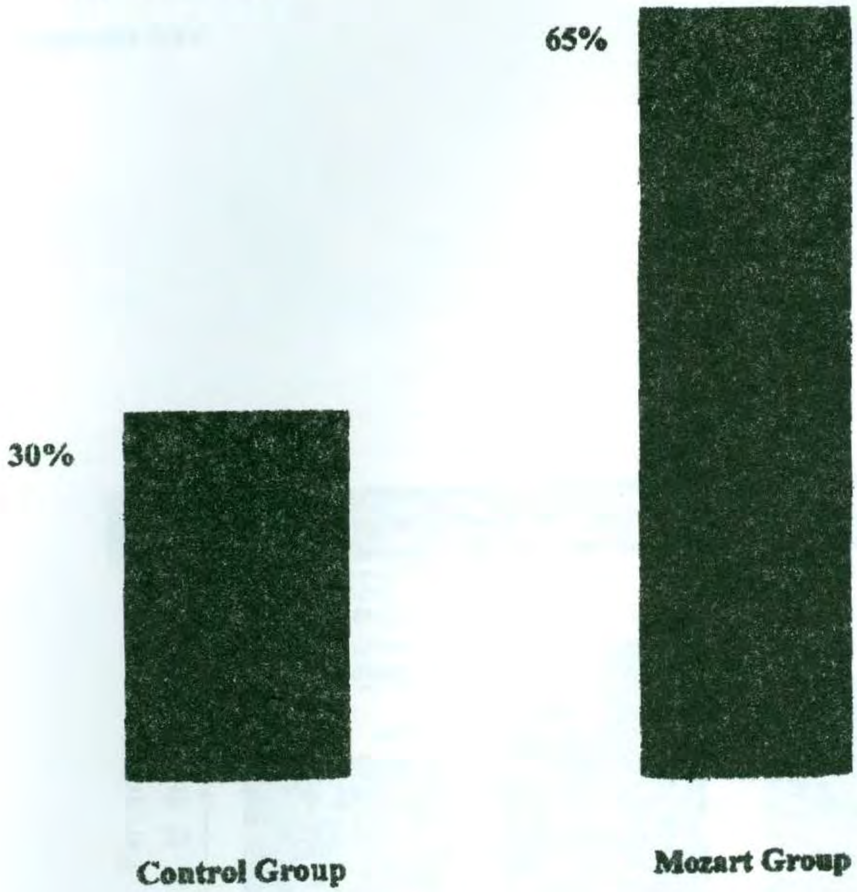
Appendix XII

DOT-TO-DOT-TO-DOT!

Look at each pattern.
Draw the rest of each pattern.

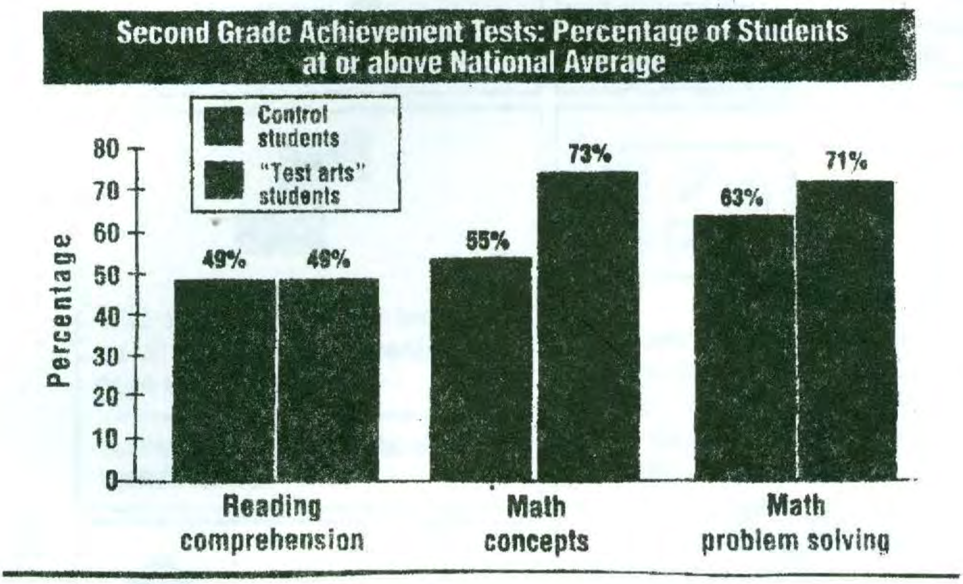


Appendix XIII



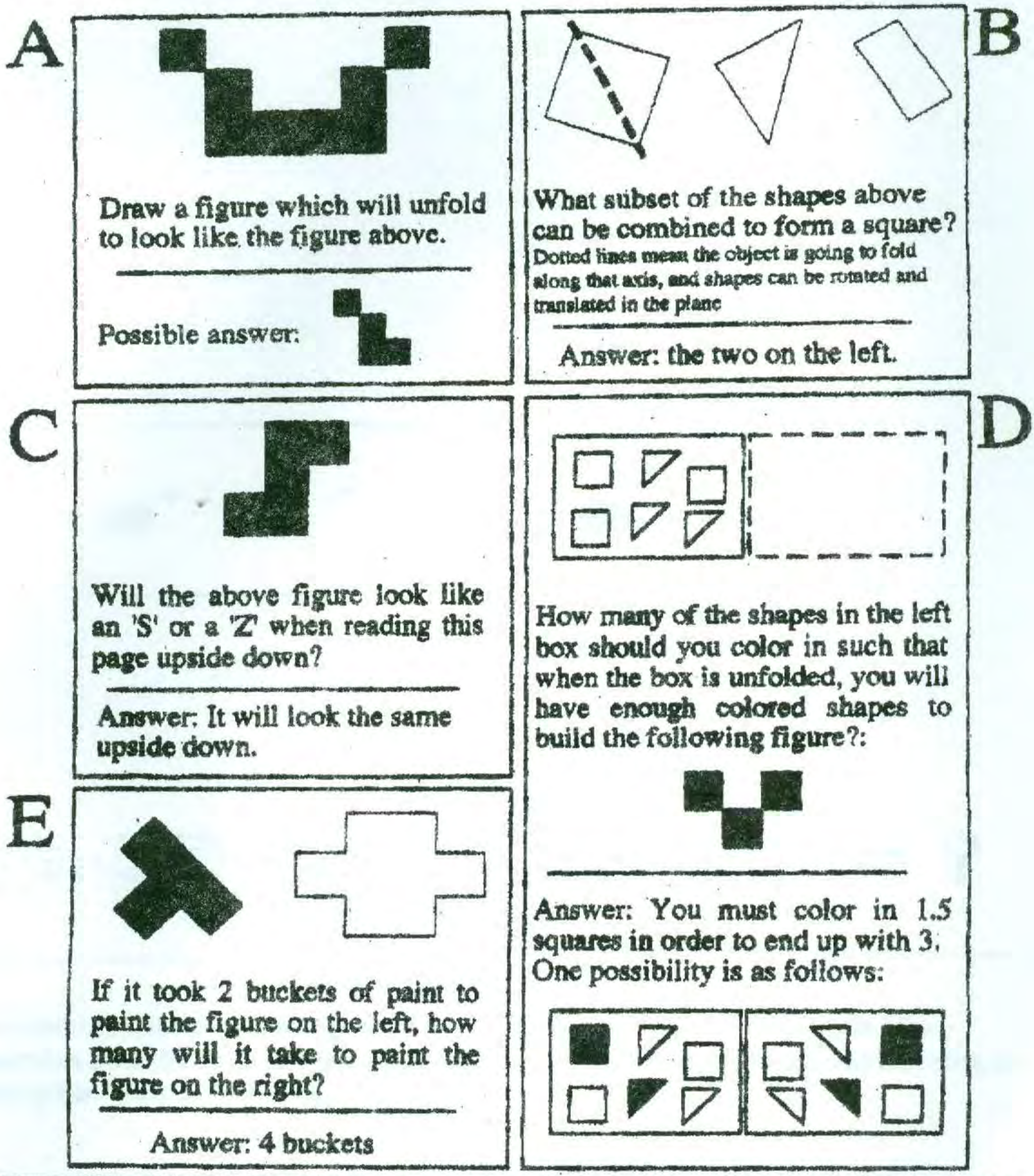
Pattern-Completion Test

Appendix XIV



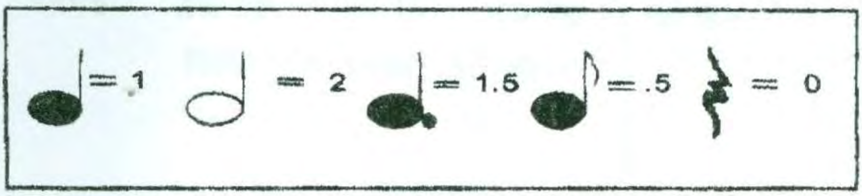
The "test arts" students started below the control group students on the Metropolitan Achievement Test. At the end of the study the "test arts" students in the Kodaly music program were at the same level in reading as the control group and above the control group in math. Source. Gardiner *et al.* (1996)

Appendix XV



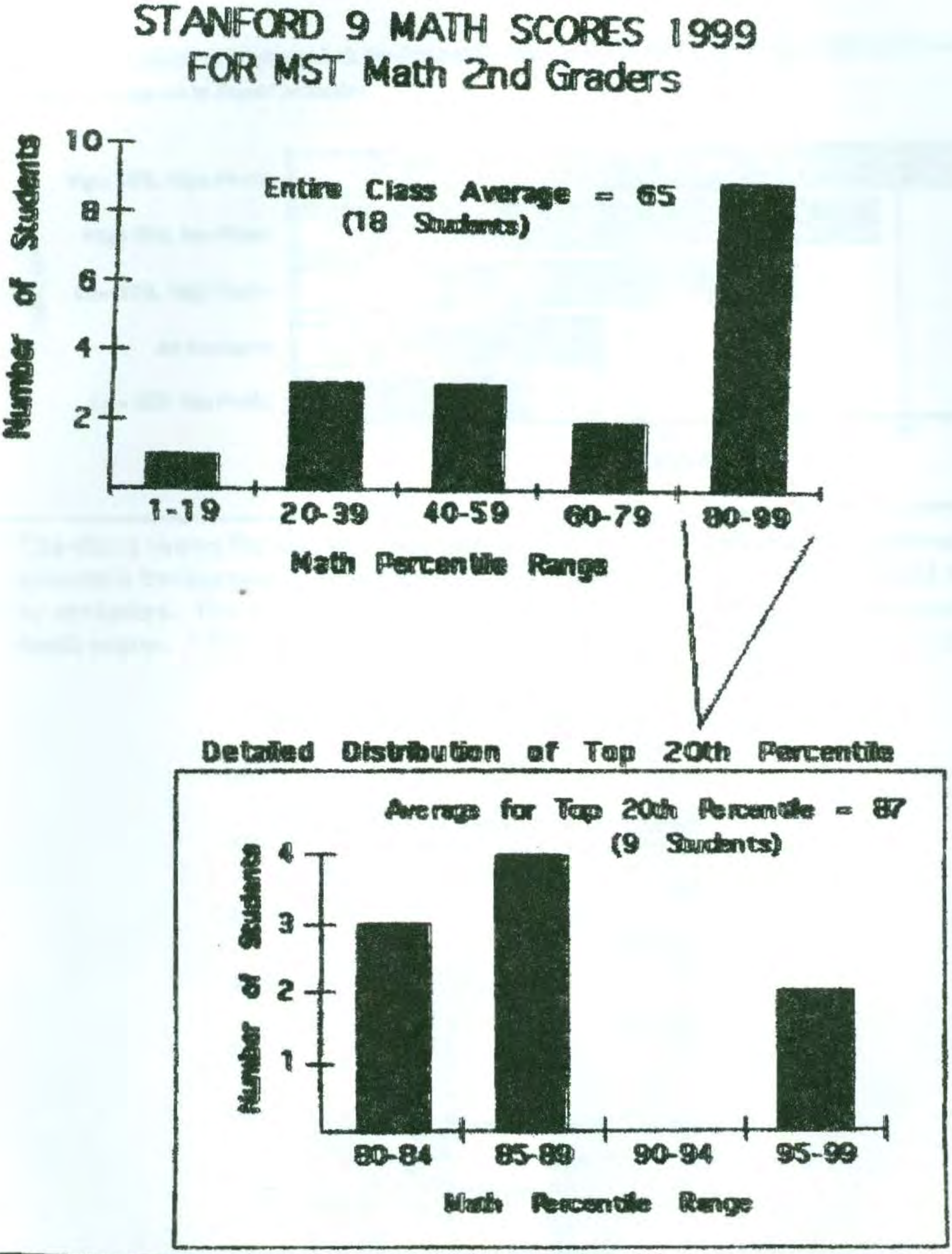
Example of the concepts introduced in the STAR Math Video Game. The verbal explanation does not appear on the actual video, which is void of any verbal instruction. Source. Peterson *et al.* (2001)

Appendix XVI



The example shows task integration in the math program. The example also illustrates how the second grade students can transfer spatial-temporal learning to math skills. Source. Peterson *et al.* (2001)

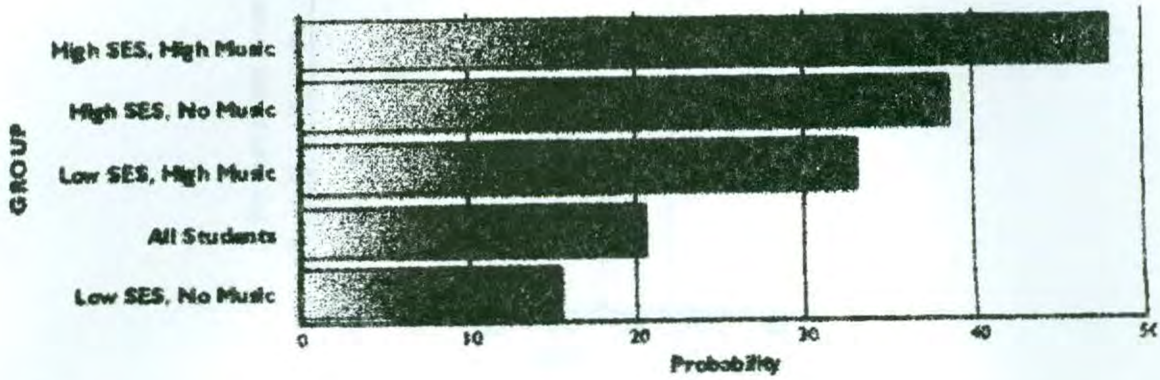
Appendix XVII



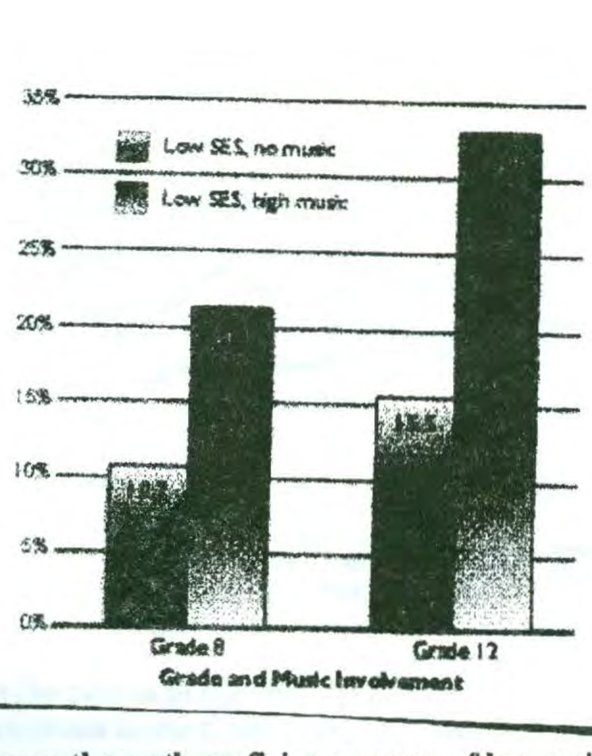
Results of the integrative math program based on the second grade students' Stanford 9 math scores. Source. Peterson *et al.* (2001)

Appendix XVIII

Figure 8. Probability of Highest Math Proficiency (Levels 4 or 5), Grade 12, By Group—SES and Consistent High vs. No Involvement in Band/Orchestra

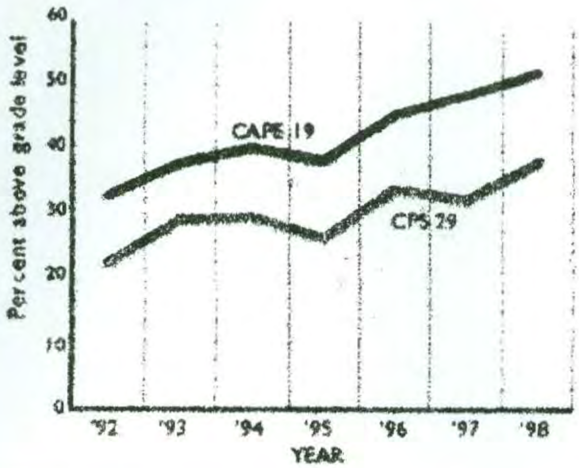


The chart shows the math proficiency of twelfth grade students from different socio-economic backgrounds. The students participating in music were involved in band or orchestra. The higher student involvement in music produced higher student math scores. " Champions of Change: The Impact of the Arts on Learning". (2000)

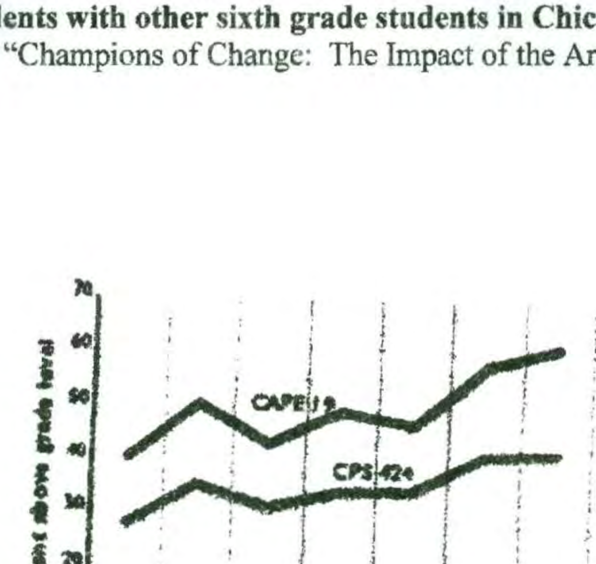


The chart compares the math proficiency scores of low socio-economic students involved in instrumental music to low socio-economic not involved in music. Source. "Champions of Change: The Impact of the Arts on Learning". (2000)

Appendix XIX



The chart compares the Illinois Goals Assessment Program reading scores to sixth grade CAPE students with other sixth grade students in Chicago Elementary Schools. Source. "Champions of Change: The Impact of the Arts on Learning". (2000)



The chart shows the results of the Illinois Goals and Assessment Program math test for sixth grade students in the CAPE program and for sixth grade students in other Chicago Elementary Schools. "Champions of Change: The Impact of the Arts on Learning". (2000)